



Sensing and Awareness in Microsystems

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Stretchable Electronics – From Hemispherical Imagers to Neural Monitors

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Summary

The Problem:

Conventional electronics are rigid, brittle and planar, thereby restricting application possibilities

The Solution:

New ways to use old materials enable soft, elastomeric and curvilinear electronics, with performance equal to conventional systems

The Opportunity:

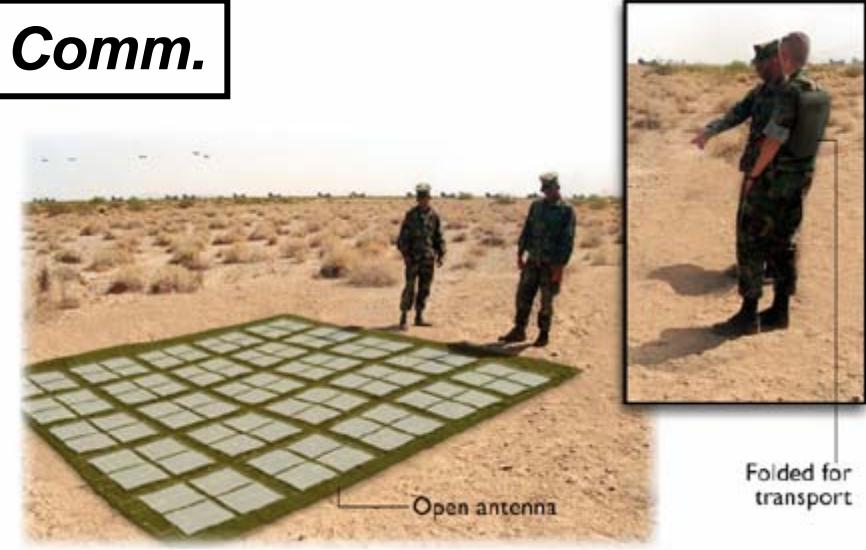
Stretchable electronics can be used for many new classes of application, with important military implications

Stretchable, Curvilinear, Large Area, Rugged and High Perf.

Imagers



Comm.



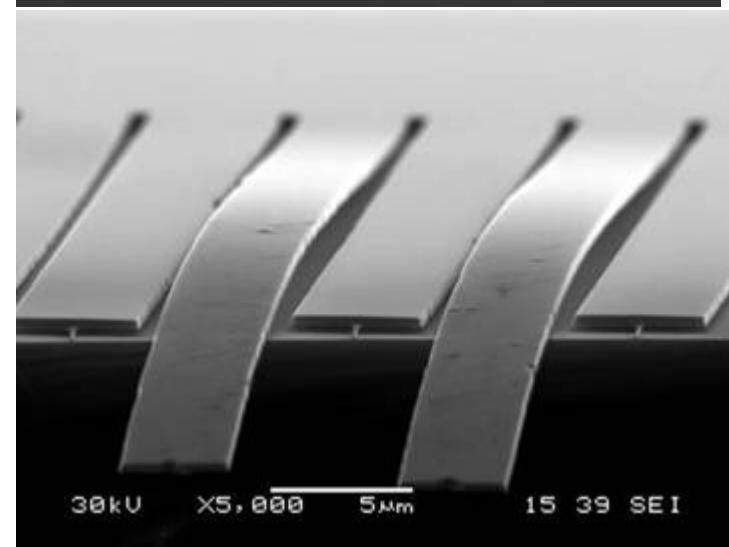
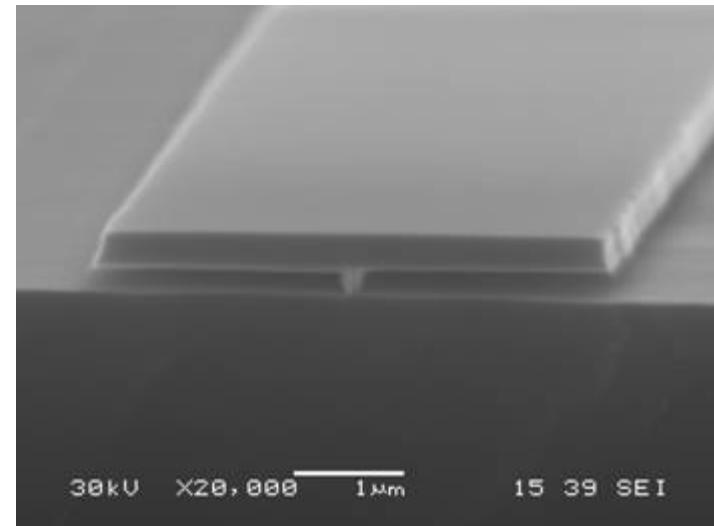
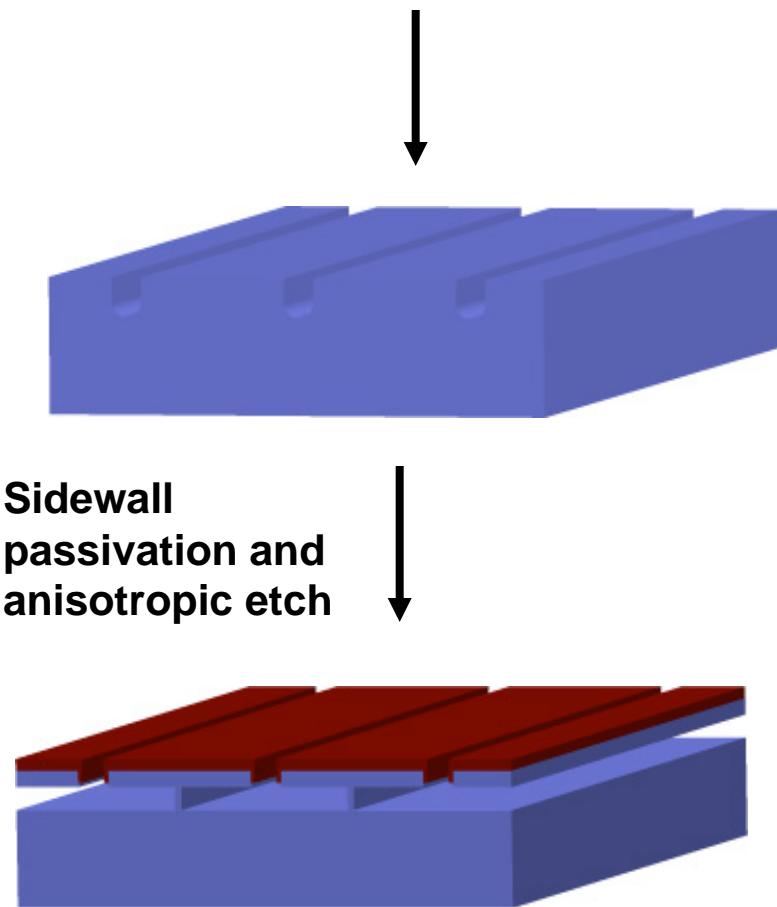
Control



Struct. Health



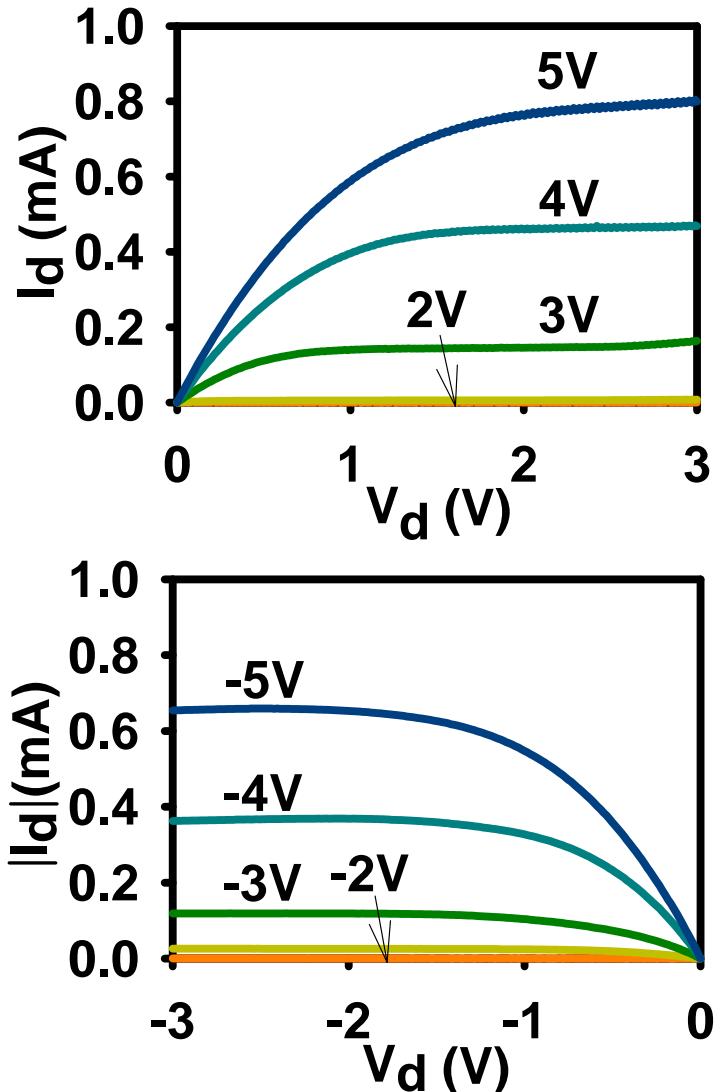
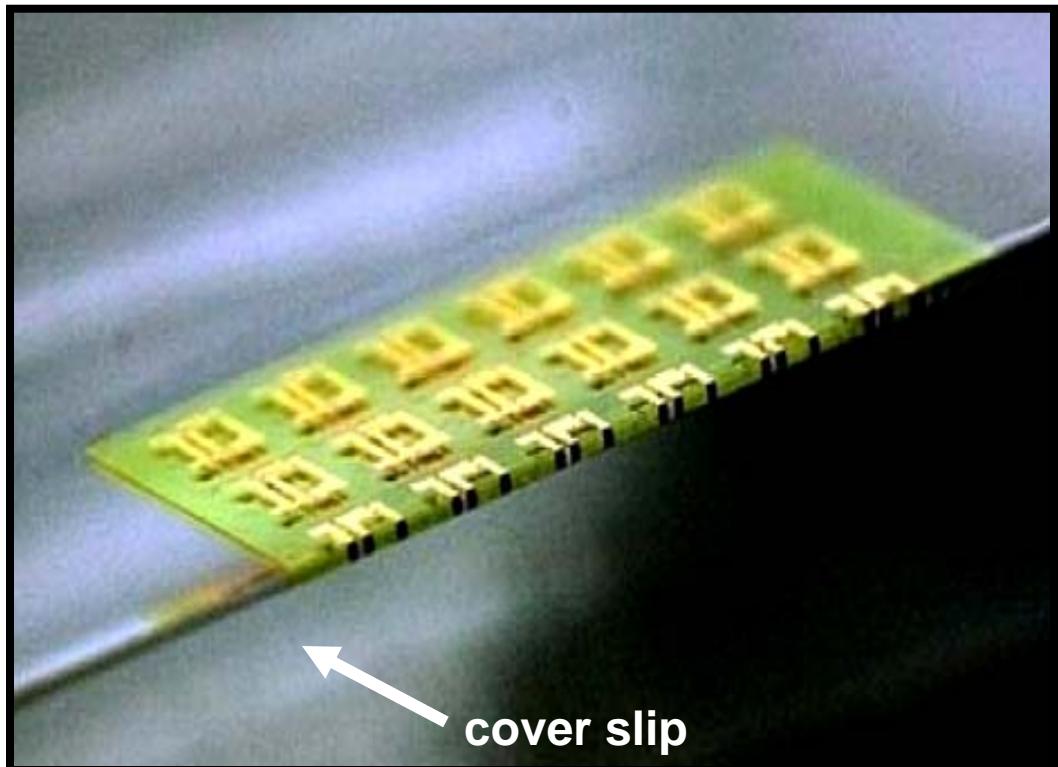
Si Nanoribbons from Bulk Wafers



Appl. Phys. Lett. **88**, 213101 (2006).

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Si CMOS and Extreme Bendability

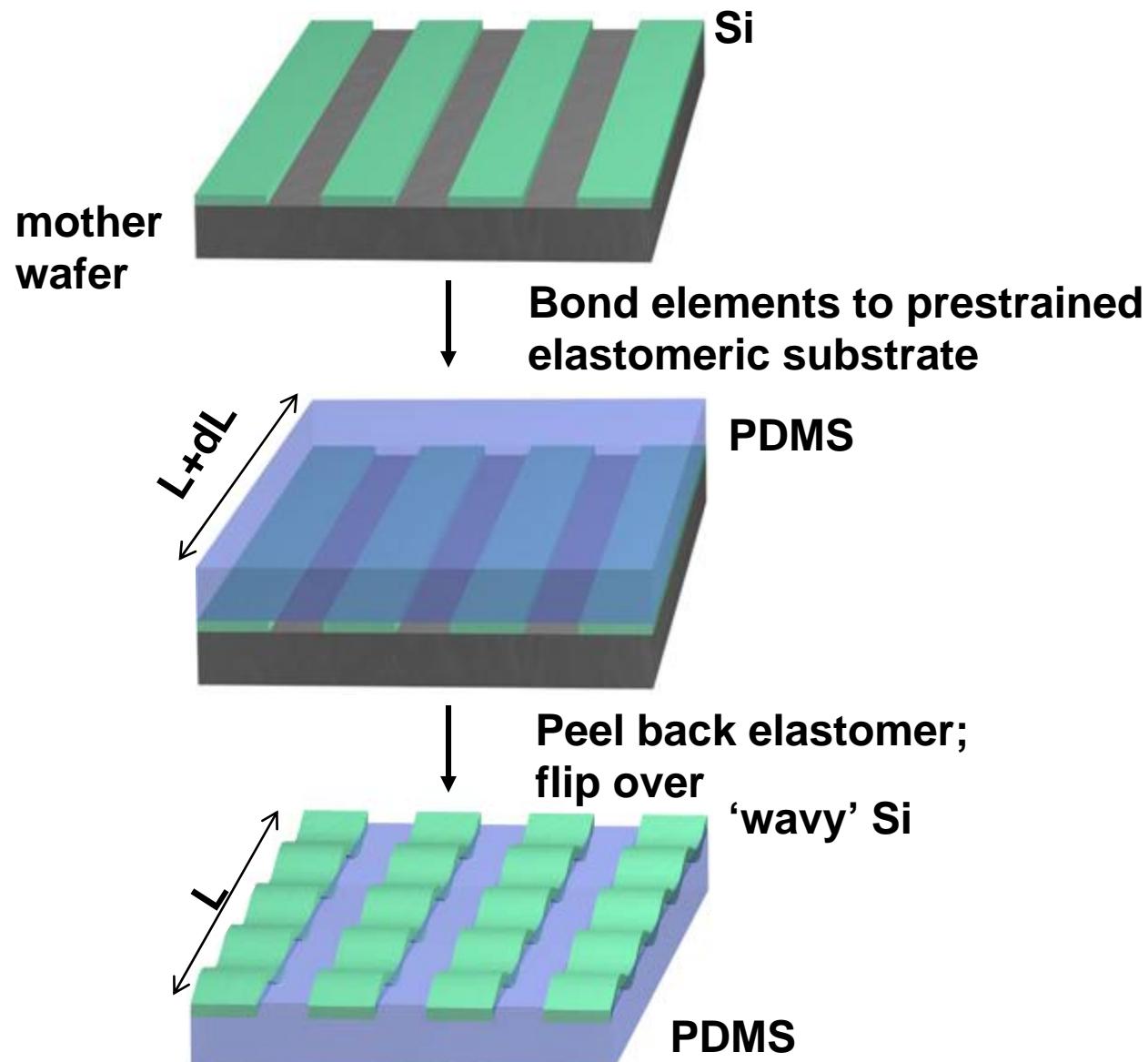


Adv. Func. Mater. **18**, 2673 (2008). *IEEE EDL* **29**, 73 (2008).

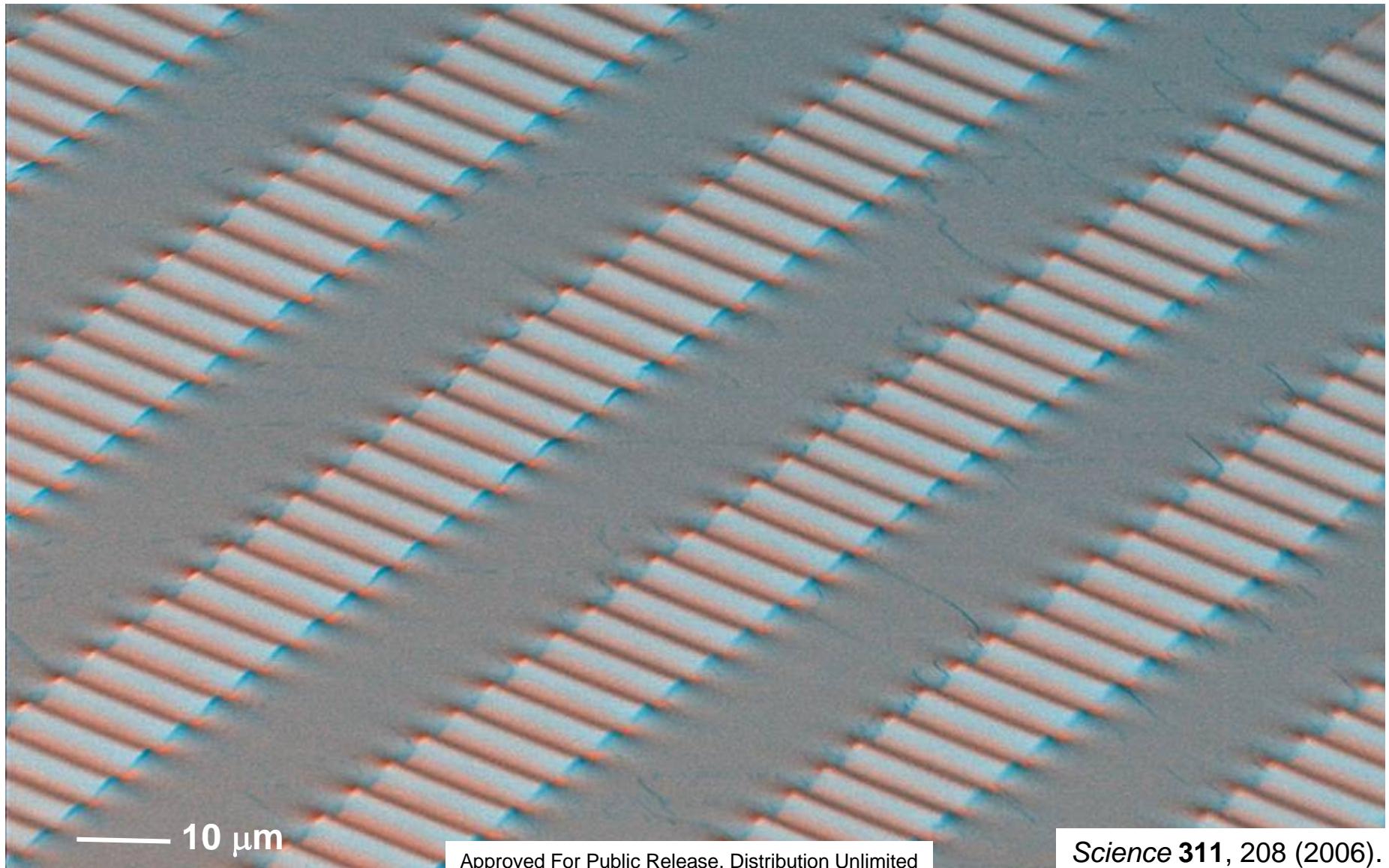
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Science **320**, 507 (2008).

A Stretchable Form of Single Crystal Silicon



Stretchable Single Crystal Silicon – ‘Wavy’ Si on Rubber

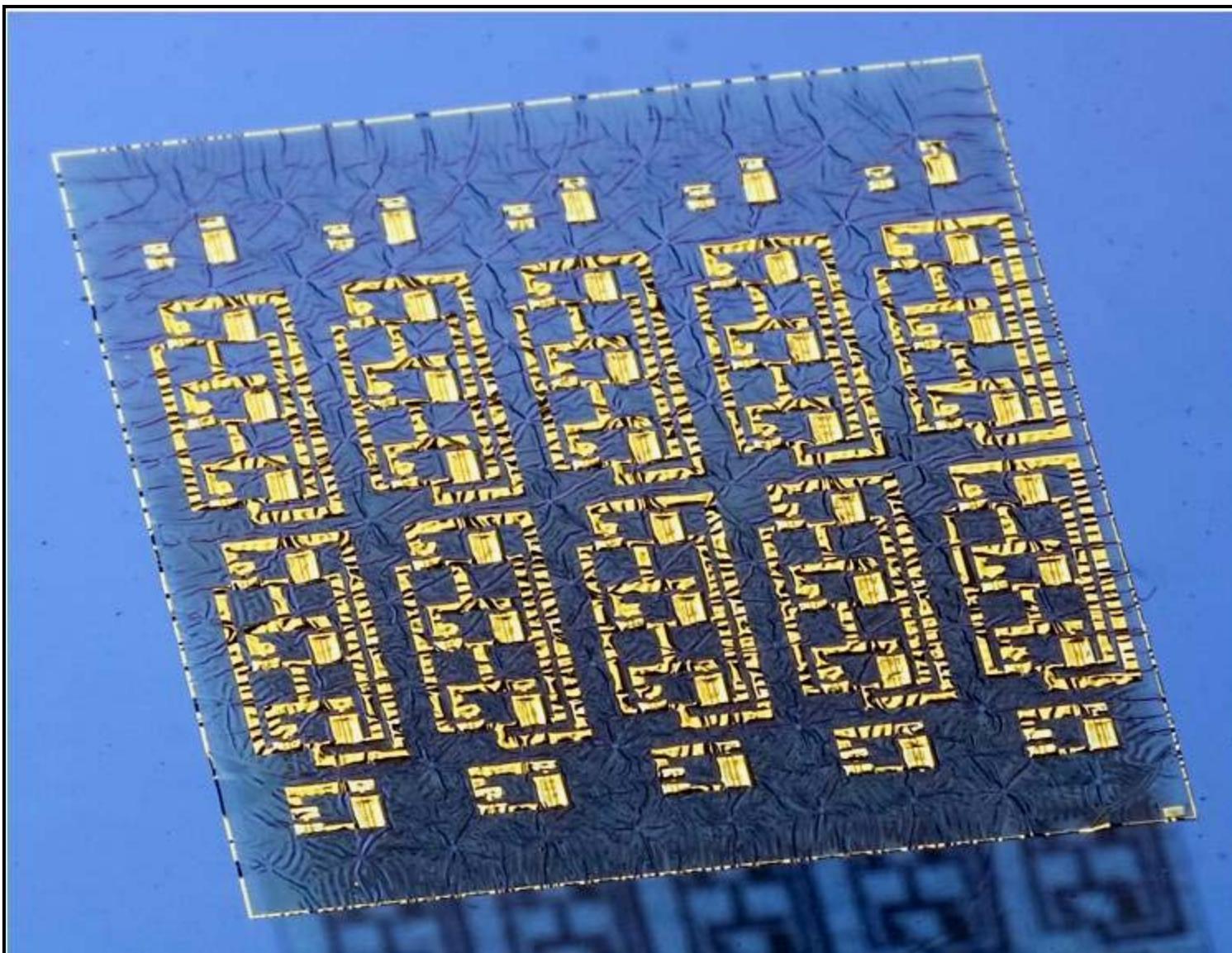


— 10 μm

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Science 311, 208 (2006).

Stretchable Silicon Integrated Circuits

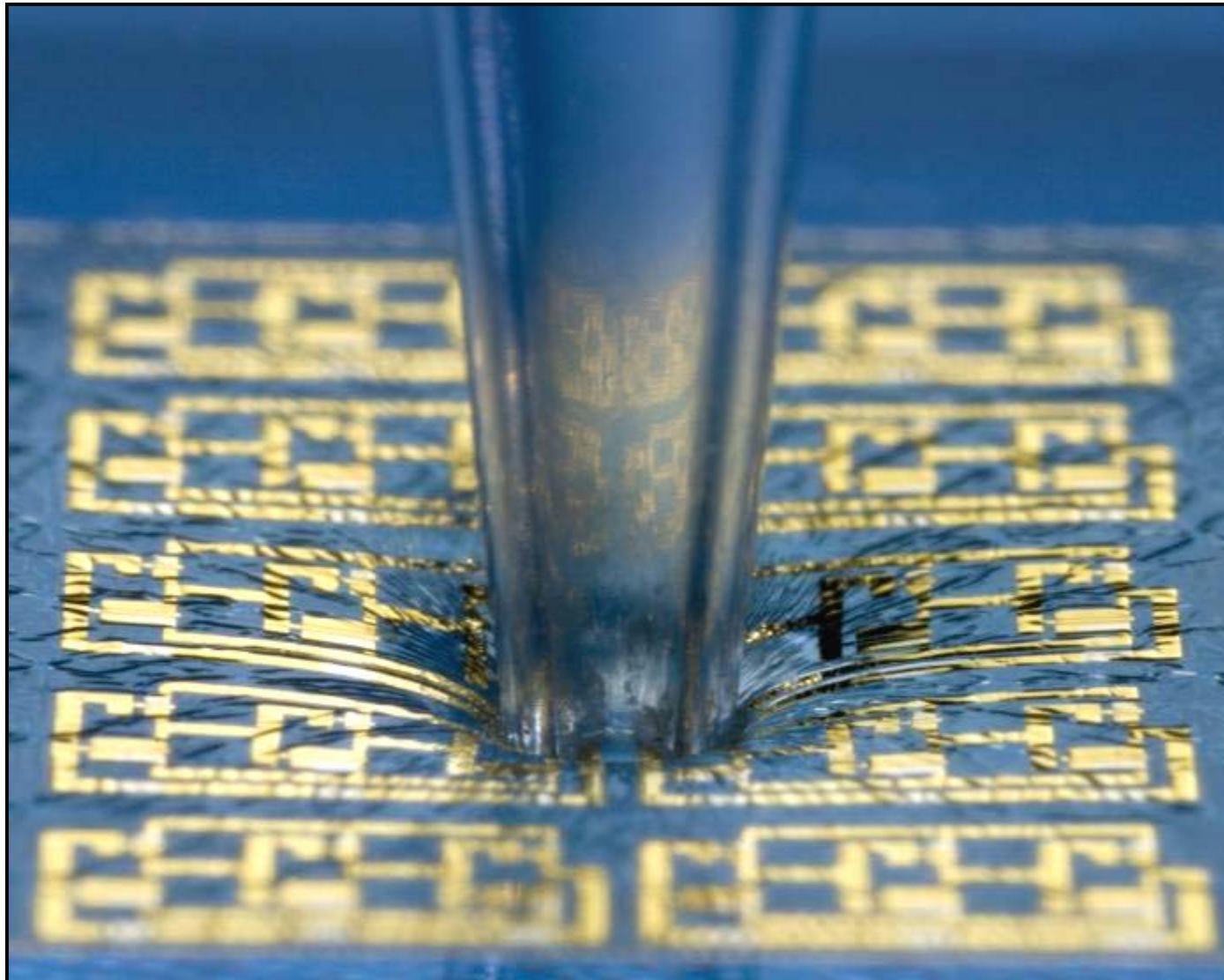


— 0.5 mm

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Science **320**, 507 (2008).

Stretchable Silicon Integrated Circuits

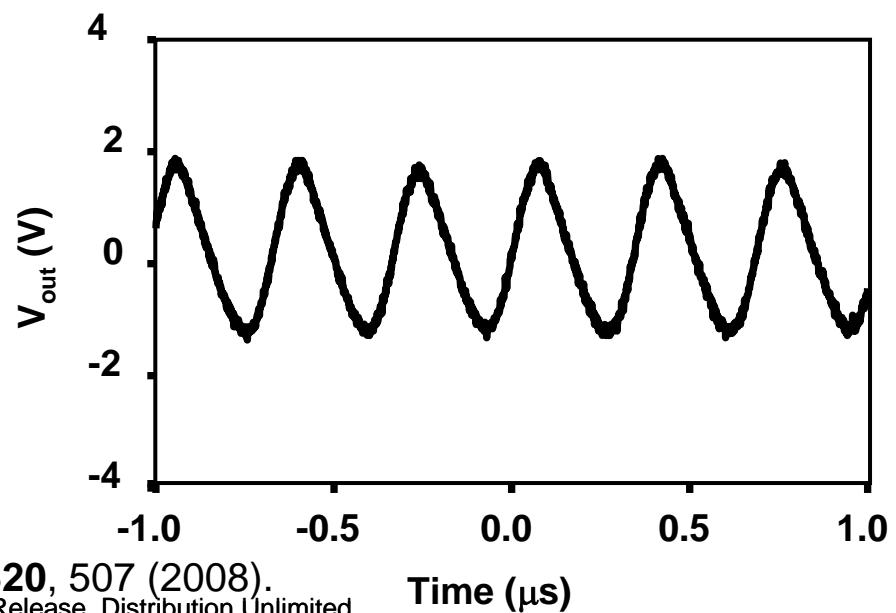
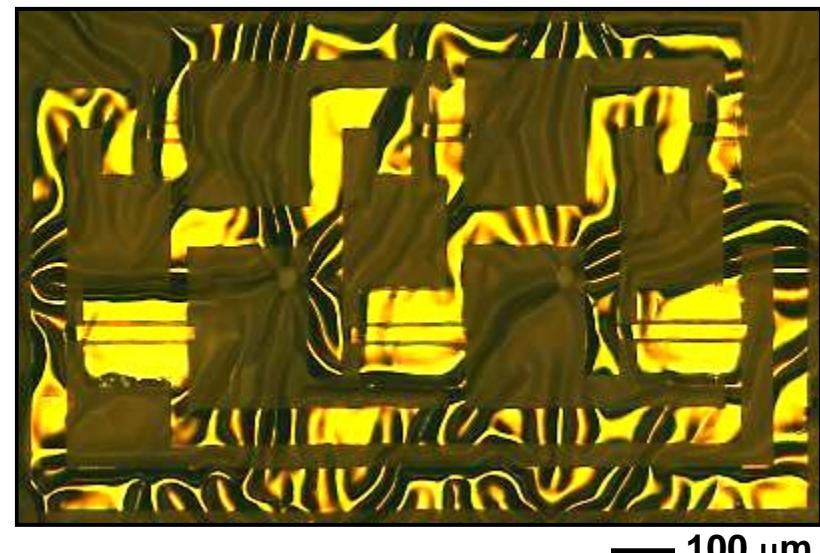
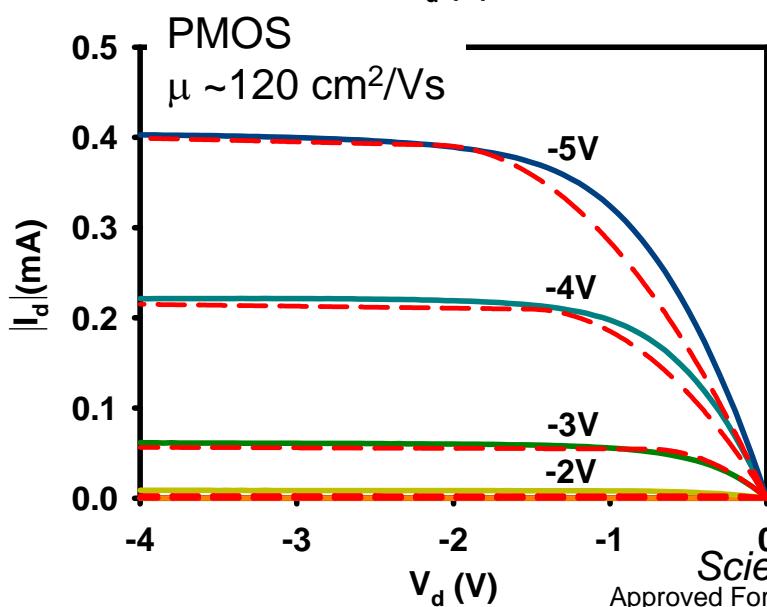
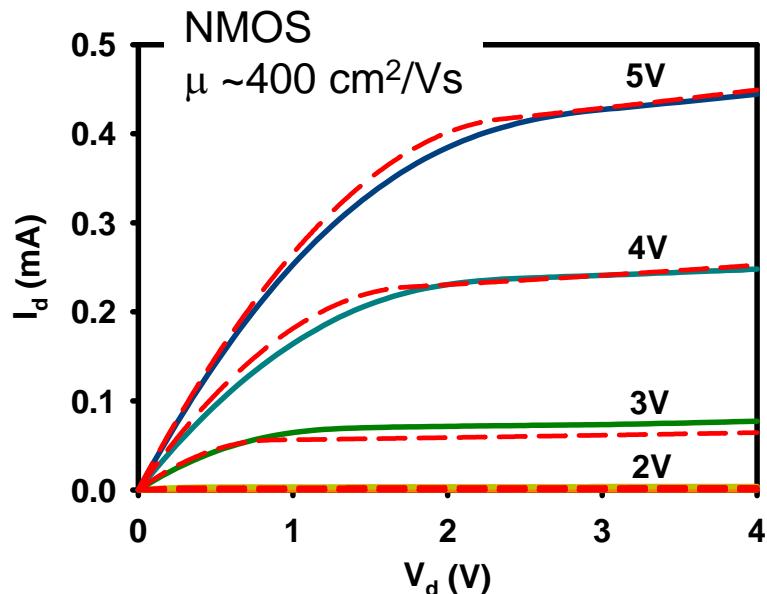


0.5 mm

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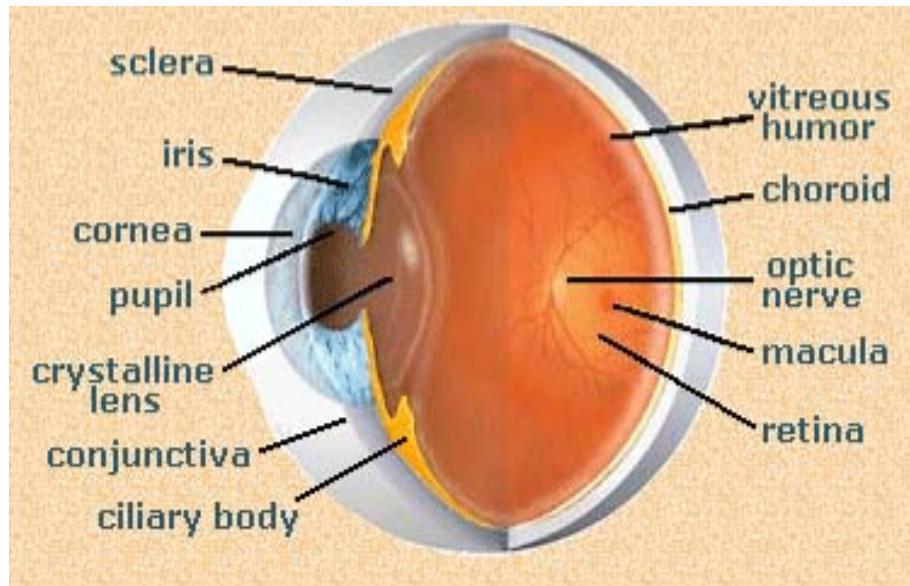
Science **320**, 507 (2008).

Stretchable Silicon Integrated Circuits

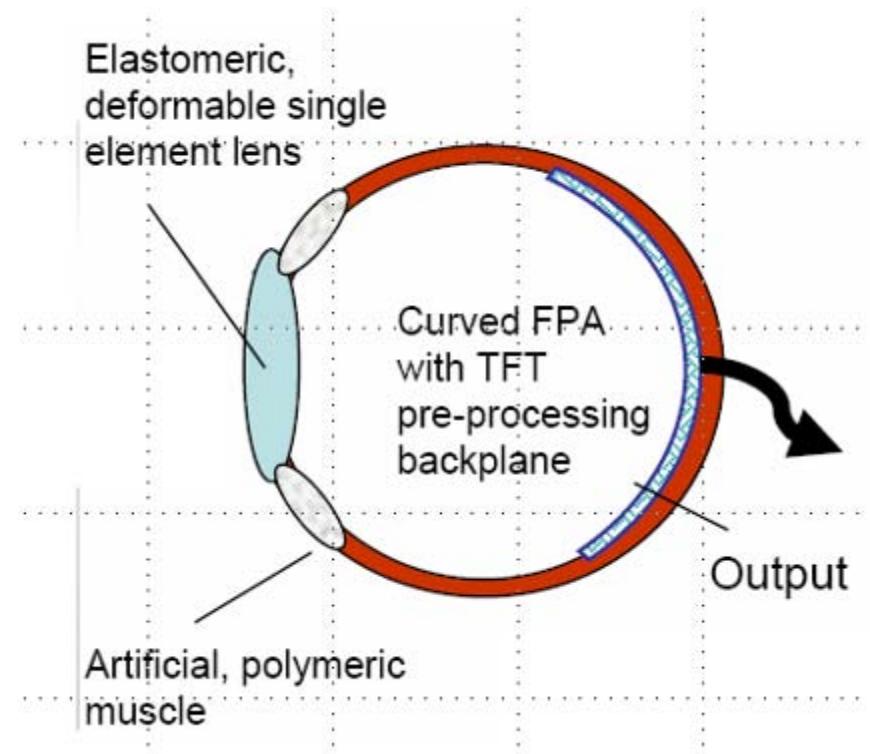


Curved Focal Plane Arrays for Wide FOV Imagers

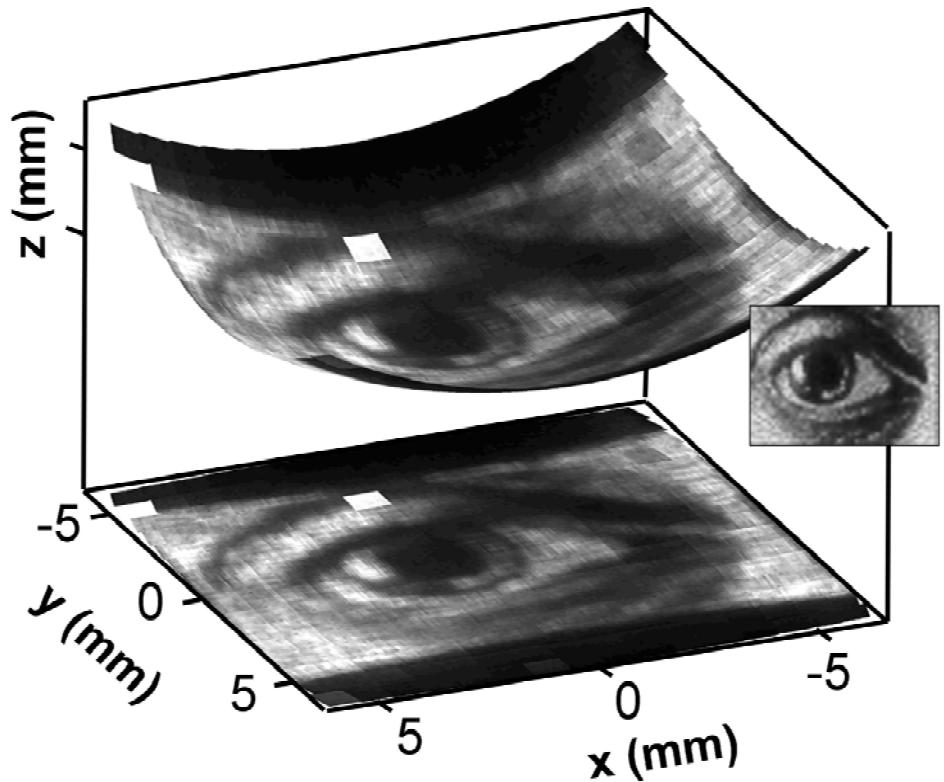
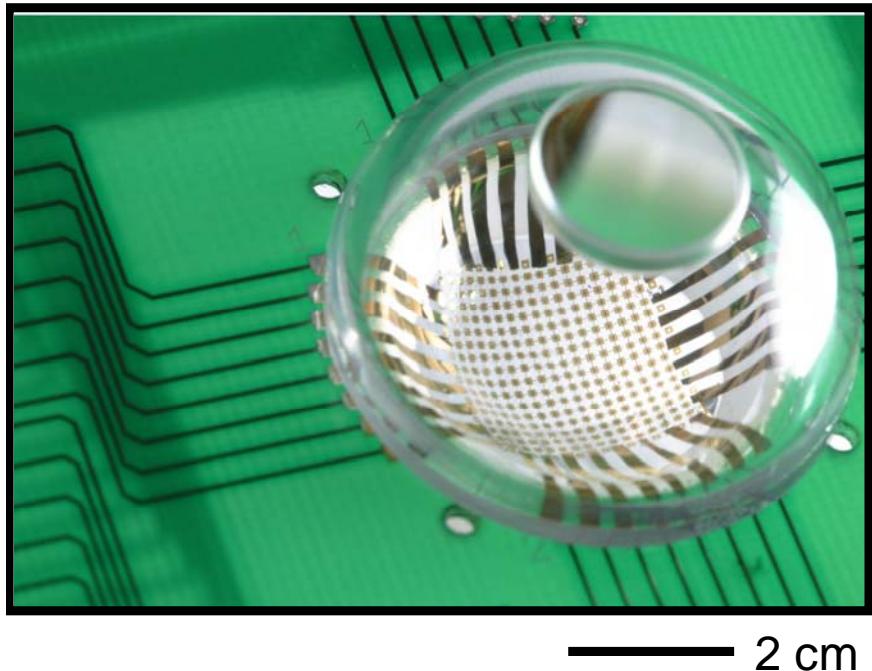
Human Eye



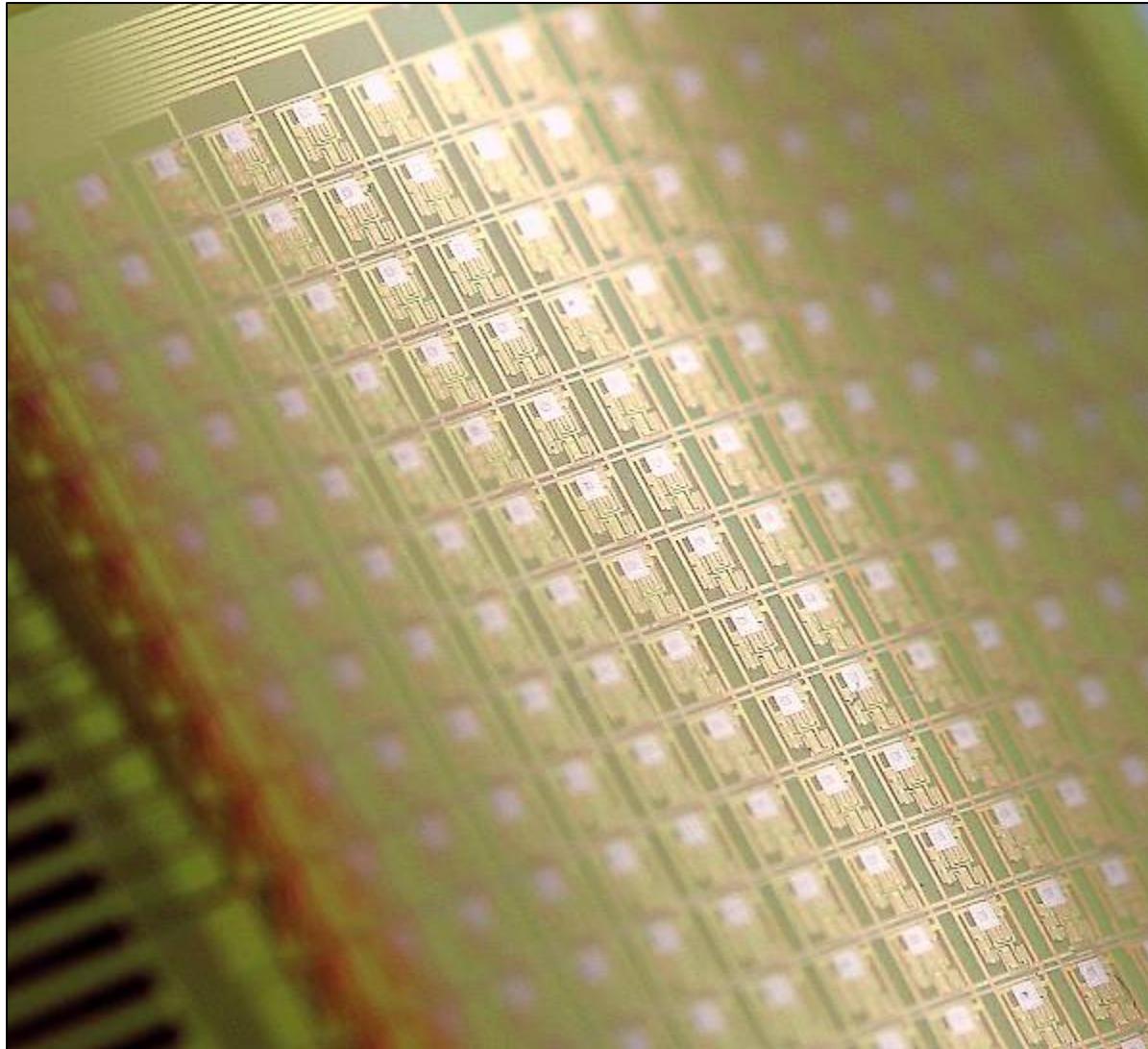
Electronic Eye



Electronic Eye via Stretchable Electronics



Active Neural Sensors – ECoG Tapes (w/ Litt)

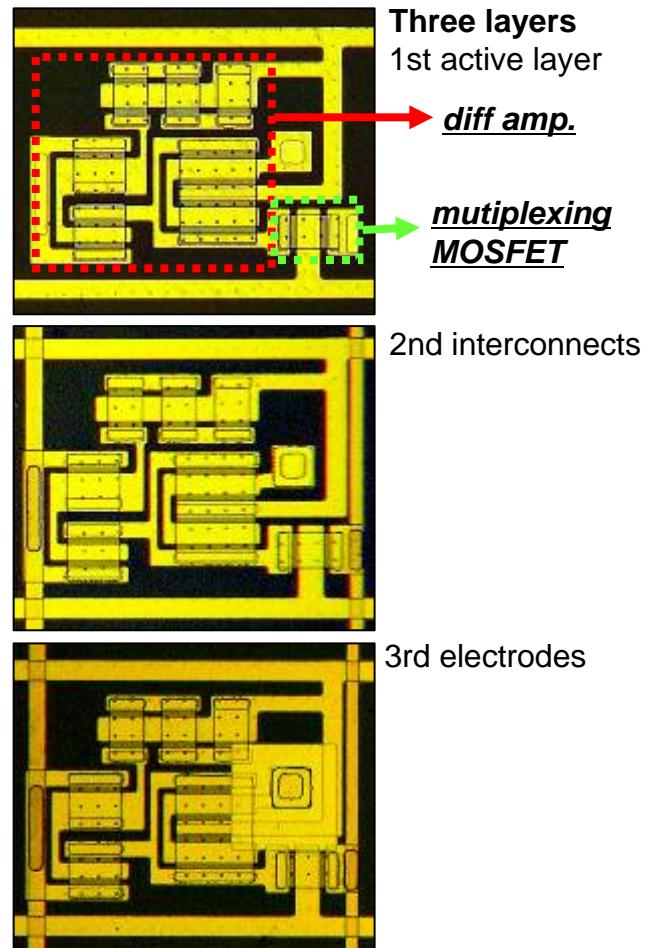


unpublished

— 1 mm

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— 200 μ m



- 288 (16×18) Sensor Array
- Multiplexing Capability
- $288 \times 7 = 2016$ transistors

Three layers
1st active layer

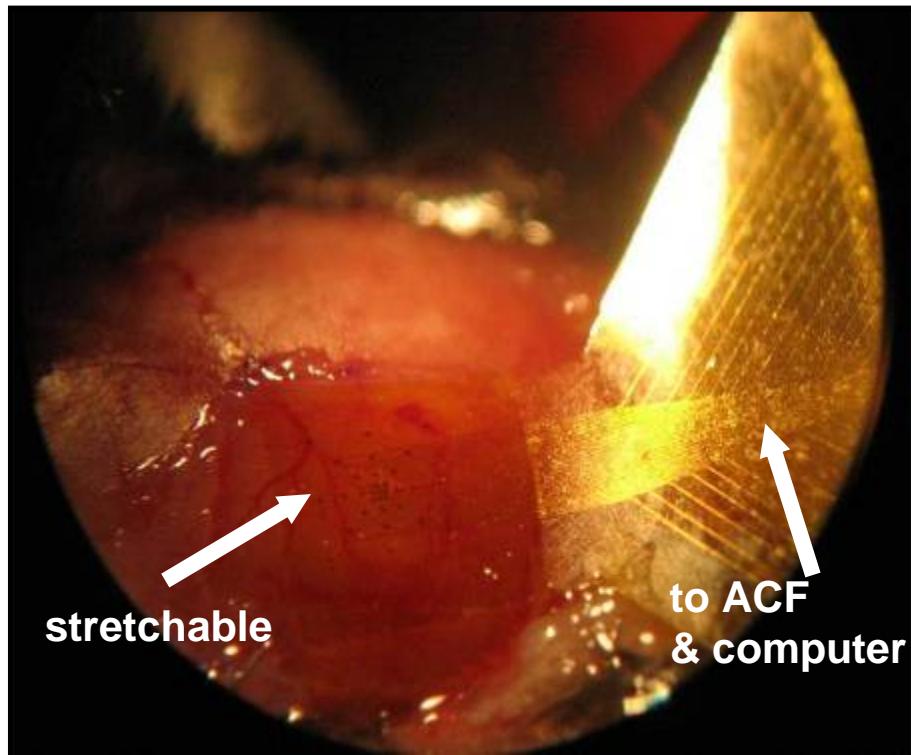
diff amp.
multiplexing
MOSFET

2nd interconnects

3rd electrodes

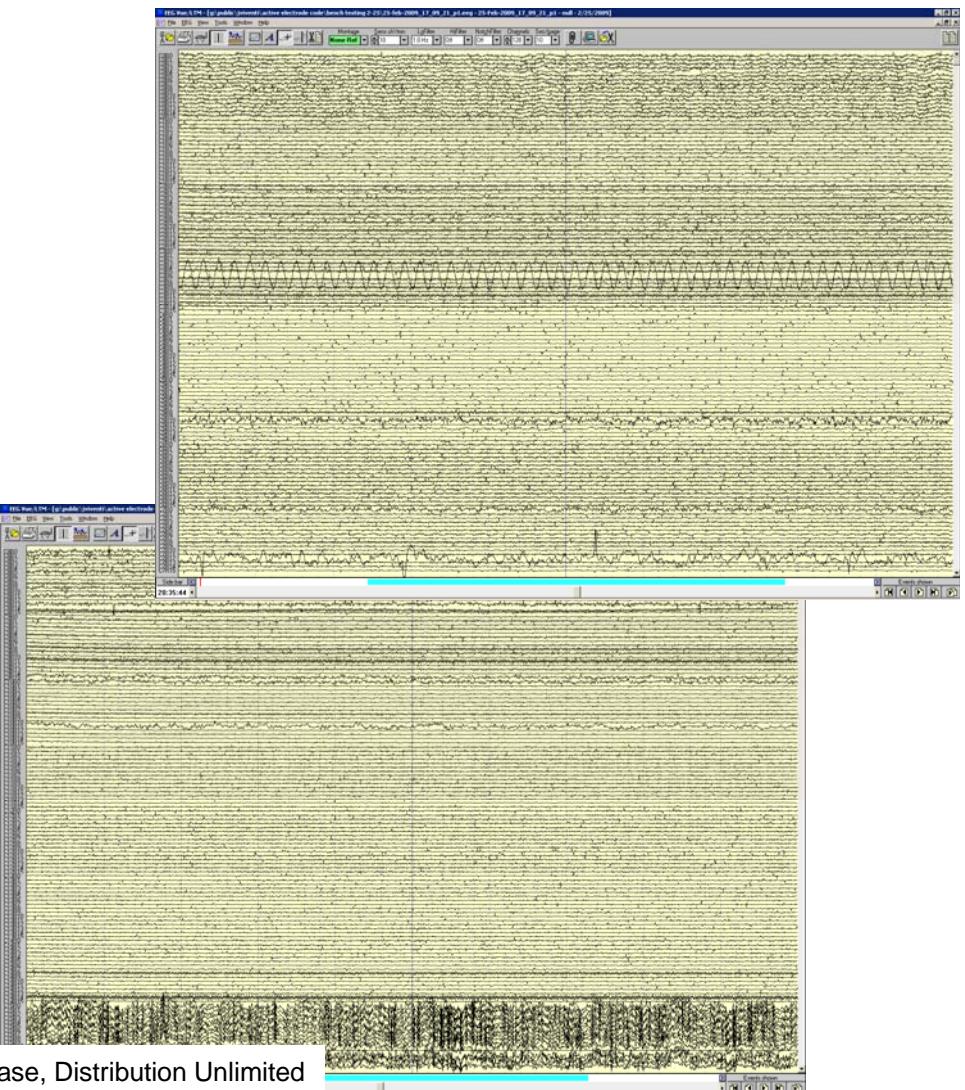
Stretchable Electronics for Brain Monitoring (w/ Litt)

Barrel Cortex in a Rat



unpublished

256 channels; 500 Hz sampling



Stretchable Electronics – From Hemispherical Imagers to Neural Monitors

Semiconductor ribbons, membranes represent promising materials for unusual format electronics

‘Wavy’ versions of these materials enable stretchable electronics: bio-inspired designs and biomedical devices

Electronic eye cameras and neural monitors provide examples

Senior Collaborators

Prof. Y. Huang (Northwestern) – mechanics theory

Prof. P. Ferreira (UIUC) – printer manufacturing systems

Prof. B. Litt (U. Penn) – cardiac, neural testing

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People



MICROSYSTEMS TECHNOLOGY OFFICE



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FROM THE INSIDE OUT

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